Ventricular ectopic activity after premature atrial beats in acute myocardial infarction[1]

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Ventricular ectopic activity occurred only after premature atrial beats in a patient with an acute inferior wall myocardial infarction. The ventricular ectopic activity occurred only when the coupling interval between the premature atrial beats and preceding sinus beat was ≤0·44 s. The sinus cycle length, however, appeared to influence the form of expression of ventricular ectopic activity independent of coupling intervals, with single premature ventricular contractions occurring at cycle lengths ≥0·72 s, couplets at cycle lengths of 0·68 to 0·71 s, and ventricular tachycardia at cycle lengths ≤0·67 s.

Ventricular premature beats may forewarn of more serious arrhythmias in the setting of acute myocardial ischaemia or infarction. The degree of prematurity has been a recognised association with the precipitation of more serious ventricular ectopic activity and sudden death for many years (Smirk and Palmer, 1960); but it has recently been emphasised that late-coupled ventricular premature beats may be equally hazardous (Lie *et al.*, 1975; El-Sherif *et al.*, 1976). In addition, the role of the underlying heart rate in predisposing to ventricular ectopic activity in acute myocardial ischaemia and/or infarction has received considerable attention (Han, 1969; Zipes and Knoebel, 1972). The initial emphasis on the relation between bradycardia and propensity to ventricular ectopic activity (Lown *et al.*, 1967; Han, 1969) was followed by observations that underlying tachycardia may also be arrhythmogenic (Scherlag *et al.*, 1970; Zipes and Knoebel, 1972). Recently, the concept of an optimal rate is beginning to evolve (Chadda *et al.*, 1974).

While the coexistence of ventricular ectopic activity and premature atrial beats has been commented upon (Scherf and Schott, 1973; Huppert and Berliner, 1975) no direct relations were noted until Wellens *et al.* (1974) showed the ability to trigger ventricular tachycardia with appropriately-timed premature atrial beats in a patient with Wolff-Parkinson-White syndrome and myocardial infarction. In the same report, they described the ability to terminate ventricular tachycardia with an appropriately timed premature atrial beat in the absence of Wolff-Parkinson-White syndrome in a patient with chronic recurrent ventricular tachycardia.

We have recently had the opportunity to see a patient who had an acute myocardial infarction and a unique relation between premature atrial beats and ventricular ectopic activity. The analysis of electrophysiological events occurring in this patient called forth considerations of the interrelation between (1) heart rate, (2) the degree of prematurity of ectopic beats, (3) the occurrence of ventricular ectopic activity, and (4) the form of expression of ventricular ectopic activity.

Case report

A 79-year-old man was admitted to the Coronary Care Unit at Jackson Memorial Hospital on 24 December 1975 because of chest discomfort and electrocardiographic evidence of inferior wall myocardial infarction. His electrocardiogram on admission showed atrial fibrillation with complete heart block, and a junctional escape rhythm at a rate of 40/min. The QRS complexes were narrow, and ST segment elevation was present in leads II, III, and aVF. Enzyme levels showed a peak CK of 674 units 18 hours after admission (normal = < 50), a peak SGOT of 208 units at 18 hours (normal = < 20 units), and a peak HBD of 878 units at 52 hours (normal = < 110 units). On the evening of 25 December 1975, a rhythm strip recorded from a continuous monitor revealed that the patient was in normal sinus rhythm with both
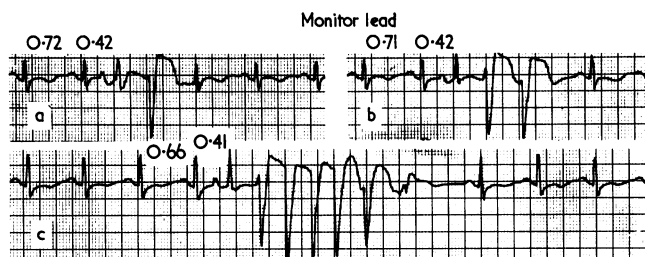
Fig. 1 *Three short rhythm strips showing the relation between sinus cycle lengths preceding premature atrial beats and the form of ventricular ectopic activity following premature atrial beats. The numbers represent coupling intervals between QRS complexes in seconds. Panel a shows a single premature ventricular contraction following a premature atrial beat. Panel b shows a pair of premature ventricular contractions following a premature atrial beat. Panel c shows a short burst of ventricular tachycardia following a premature atrial beat.*

premature atrial beats and ventricular ectopic activity. A two-minute rhythm strip, recorded before starting treatment for the ventricular ectopic activity showed single ventricular premature beats, pairs of ventricular premature beats, and short runs of ventricular tachycardia (Fig. 1). A bolus of lignocaine, 75 mg i.v., had no effect on either the premature atrial beats or ventricular ectopic activity. A second 75 mg i.v. bolus of lignocaine, followed by an i.v. infusion at a rate of 2 mg/min, had no effect on the rhythm disturbance and caused hypotension. The lignocaine infusion was discontinued, and a total of 500 mg procainamide in 100 mg boluses 10 to 15 minutes apart was administered, but did not influence the arrhythmia. Quinidine sulphate, 400 mg every 6 hours by mouth, was instituted next because of the failure of lignocaine and procainamide. Over the next 12 hours, both the premature atrial beats and ventricular ectopic activity decreased in frequency and finally abated together. The patient was maintained on quinidine sulphate, and had no further ventricular ectopic activity or premature atrial beats. The remainder of his hospital course was uncomplicated, and he was discharged on 9 January 1976.

The patient was readmitted on 26 March 1976 for intracardiac electrophysiological studies. Quinidine sulphate was stopped 48 hours before the study. The atrioventricular nodal conduction time (AH interval) was normal, as was the corrected sinus node recovery time. The HV interval was 55 ms during normal sinus rhythm (normal = 35–55 ms), and the V-RVA interval was 15 ms. During normal sinus rhythm at a cycle length of 740 ms, coupled premature atrial stimuli at a coupling interval of 430 ms resulted in aberrant intraventricular conduction (incomplete RBBB) of the premature beats, with a prolongation of the V-RVA interval from 15 to 25 ms. No ventricular ectopic activity was elicited at any coupling interval, nor during premature atrial stimulation at a shorter basic cycle length (500 ms) induced by atrial pacing. No evidence of bypass tracts was recorded.

Electrocardiographic analysis

During the period of time that the patient showed ventricular ectopic activity, all such activity was preceded by conducted premature atrial beats. All of the conducted premature atrial beats had terminal QRS delays, caused by aberrant intraventricular conduction. Panel a in Fig. 1 shows a premature atrial beat preceding a single premature ventricular beat, the patient then resuming normal sinus rhythm. Panel b shows a premature atrial beat followed by a pair of premature beats, again with subsequent return of normal sinus rhythm. In Panel c, a single premature atrial beat precedes a short burst of ventricular tachycardia. These tracings are representative of the premature atrial beat/ventricular ectopic activity relations recorded during the time that the arrhythmias persisted. In Fig. 2, the top tracing shows a premature atrial beat followed by a single premature ventricular beat, and the lower tracing shows two premature atrial beats which were not followed by ventricular ectopic activity. All of the electrocardiographic data available showing premature atrial beats, with and without ventricular ectopic activity, was analysed to determine the time relations between the underlying sinus cycle lengths, the coupling intervals between the QRS complexes, following sinus beats and premature atrial beats, and the
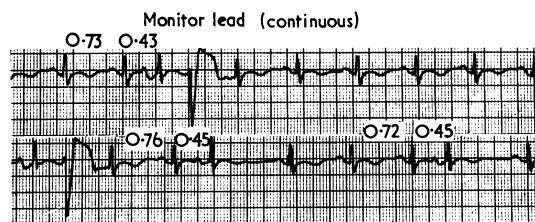
Fig. 2 *Continuous rhythm strip showing premature atrial beats followed by single premature ventricular contractions, and premature atrial beats (lower tracing) not followed by ventricular ectopic activity.*

occurrence and type of ventricular ectopic activity. Fig. 3 shows this analysis graphically: the abscissa represents the intervals between the QRS complexes of the sinus cycles preceding each premature atrial beat (labelled 'RR interval'), and the ordinate shows the coupling interval between the QRS complexes of sinus beats and the QRS complexes of premature atrial beats (labelled 'RR′ interval'). The occurrence of premature atrial beats without subsequent ventricular ectopic activity, and premature atrial beats followed by (1) single ventricular premature beats, (2) pairs of ventricular premature beats, or (3) short runs of ventricular tachycardia, are indicated by the symbols noted on the figure.

In no instance was a premature atrial beat with a coupling interval between QRS complexes of sinus and premature atrial origin (i.e. RR′ interval) greater than 0·44 s followed by ventricular ectopic activity. The *sinus cycle lengths* (RR intervals) immediately preceding premature atrial beats without ventricular ectopic activity ranged from 0·69 to 0·80 s. Conversely, at RR′ intervals between 0·41 and 0·44 s, ventricular ectopic activity always followed premature atrial beats. When the sinus cycle length (RR interval) preceding such 'triggering' premature atrial beats was 0·72 s or more, the ventricular ectopic activity following a premature atrial beat was always expressed in the form of a *single* premature ventricular beat, regardless of the coupling interval between the sinus beat and the premature atrial beat. The coupling intervals ranged from 0·41 to 0·44 s. When the sinus cycle length was between 0·68 and 0·71 s, ventricular ectopic activity again followed each premature atrial beat having RR′ intervals of 0·44 s or less; and in all 5 instances recorded, the ventricular ectopic activity was expressed as *pairs* of premature beats (Fig. 1b). In 5 instances in which the sinus cycle length preceding the premature atrial beat was 0·67 s or less, the consequence of appropriately timed premature atrial activity was bursts of *ventricular tachycardia* (see Fig. 1c). While there was a tendency for the coupling interval of the premature atrial beats to decrease at shorter sinus cycle lengths, this did not appear to be a discriminating factor in the determination of the type of ventricular ectopic activity that followed premature atrial beats of a given coupling interval. The ratio of the RR′ interval of the premature atrial beat to the RR interval of the preceding sinus cycle QRS complexes averaged 0·58 when single premature ventricular beats followed premature atrial beats, 0·61 when pairs of premature ventricular beats followed a premature atrial beat, and 0·65 when runs of ventricular tachycardia followed a premature atrial beat. The ratio was 0·62 when no

ventricular ectopic activity followed premature atrial beats.

The analysis of all the atrial and ventricular ectopic activity available on this patient suggests that the coupling interval between the QRS of sinus origin and the QRS of premature atrial origin (RR′ interval) was the determinant of whether or not ventricular ectopic activity followed premature atrial beats. The sinus cycle length (RR interval) preceding premature atrial beats did not influence the relation. However, once the RR′ interval was in the range that resulted in the *occurrence* of ventricular ectopic activity, the *form of expression* of the ventricular ectopic activity was determined by the sinus cycle length (RR interval) preceding the premature atrial beat, rather than by the coupling interval (RR′ interval).

Discussion

A relation between premature atrial beats and ventricular tachycardia was reported by Wellens *et al.* (1974) in a patient with acute myocardial infarction and WPW syndrome. In the same manuscript, these authors reported the ability to terminate a burst of ventricular tachycardia in a patient with chronic recurrent ventricular tachycardia with an appropriately timed premature
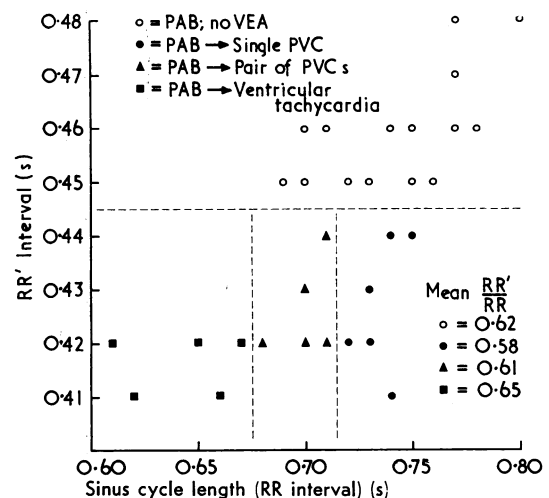

Fig. 3 *Graphic demonstration of the relation between underlying sinus rate (RR interval), degree of prematurity of the premature atrial beats (RR′ interval), and the occurrence and form of expression of ventricular ectopic activity. The RR′/RR ratio is used as an expression of the degree of prematurity of ventricular activation by premature atrial beats, as a function of sinus rate. It is not strictly analogous to the concept of the prematurity index (RR′/QT).*

atrial impulse. Subsequently, El-Sherif *et al.* (1976) reported the occurrence of ventricular fibrillation following premature atrial beats in the setting of an acute myocardial infarction. No other clinical description of premature atrial activity influencing ventricular ectopic activity in the setting of acute myocardial ischaemia or infarction has been reported before the present observation, though the occurrence of coexistent but unrelated premature atrial beats and ventricular ectopic activity has long been recognised (Huppert and Berliner, 1951; Scherf and Schott, 1973). The unique features in the present case include: (1) a prematurity-dependent determinant of the occurrence of premature atrial beat-triggered ventricular ectopic activity; (2) a sinus cycle length determinant of the form of expression of ventricular ectopic activity; and (3) the occurrence of these interrelations transiently in the setting of an acute myocardial infarction. Antiarrhythmic agents effective against ventricular ectopic activity in acute ischaemia were not effective in this patient. Ventricular ectopic activity was controlled when the premature atrial beats were controlled, suggesting a possible interrelation. Whether this was a direct result of quinidine on the atrial abnormalities alone, or upon deranged electrophysiology at both the atrial and ventricular levels, or even a consequence of the natural evolution of the acute event, can only be conjectured.

Several investigators (Scherlag *et al.*, 1970; Epstein *et al.*, 1972; Zipes and Knoebel, 1972; Waldo and Kaiser, 1973; Chadda *et al.*, 1974; El-Sherif *et al.*, 1975) have given experimental, as well as clinical, support for the concept that rapid sinus rates in the setting of an acute ischaemic event might predispose to the occurrence of malignant ventricular arrhythmias. Waldo and Kaiser (1973) and El-Sherif *et al.* (1975) have provided experimental support for such an hypothesis, based on much delayed and/or fragmented ventricular muscle activity in the area of an infarct, dependent, at least in part, upon the rate of stimulation. The local delays in activation presumably enhance the propensity for re-entrant activity. On the other hand, the relation between the degree of prematurity of ventricular activation and the propensity for potentially serious ventricular arrhythmias has long been emphasised (Smirk and Palmer, 1960). In the present case, the coupling interval between the QRS complex, following the sinus P wave before a premature atrial beat, and the QRS complex resulting from a premature atrial beat, appeared to determine whether or not premature atrial activity would be followed by ventricular ectopic activity. However, the severity of expression of the ventricular ectopic activity was dependent upon the underlying cycle length at which premature activation of the ventricles occurred.

The aberrant intraventricular conduction of the premature atrial beats might have been related to the emergence of ventricular ectopic activity. Aberrant conduction in response to premature supraventricular activity is usually a result of encroachment on the refractory period of the intraventricular specialised conducting system (Cohen *et al.*, 1968). This indeed seemed to be the case during the electrophysiological studies in our patient three months after the acute myocardial infarction. However, at the time of the arrhythmias, pathological refractoriness in either specialised conducting tissue or ordinary muscle must be considered as potential mechanisms. This mechanism might require dispersion of activation (and repolarisation) in the region of ischaemia/necrosis; and such dispersion, enhanced by both the premature activity of supraventricular origin and sinus rate variations, might have led to the forms of ventricular ectopic activity recorded.

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